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PATENT SPECIFICATION

DRAWINGS ATTACHED

Inventors: HENLEY FRANK STERLING and REGINALD WALTER WARREN

977,546

977,546

Date of Application and filing Complete Specification Jan. 10, 1963.
No. 1216/63.

(Patent of Addition to No. 871157 dated Dec. 23, 1958).

Complete Specification Published Dec. 9, 1964.

Index at acceptance: —F4 B51

International Classification: —F 27 c

COMPLETE SPECIFICATION

Improvements in or relating to Apparatus for Processing Fusible Materials

We, STANDARD TELEPHONES AND CABLES LIMITED, a British Company, of Connaught House, 63 Aldwych, London, W.C.2., England, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement: —

This invention relates to apparatus for processing fusible materials, and constitutes an improvement in or modification of the apparatus disclosed in British Patent Specification No. 871,157 (Application No. 8295/58) in which there is described and claimed a crucible made from a number of tubes of metal of high thermal and electrical conductivity, the tubes being arranged sufficiently close together for molten material to be prevented from escaping from the crucible.

In one form of crucible, shown in Fig. 2 of British Patent Specification No. 871,157, the tubes are arranged to form inverted truncated cone, the upper and lower ends of the tubes communicating with header compartments whereby a cooling fluid can be circulated through the tubes. Heating of the contents of the crucible is accomplished by surrounding the crucible with a radio frequency coil. It has been found that in such an arrangement it is difficult, when crystal pulling, to obtain the correct thermal gradients through the material in the crucible without the bottom portion of the material solidifying.

According to the present invention there is provided a crucible made from a number of tapered tubes of metal of high thermal and electrical conductivity, the tubes being arranged vertically and having their narrowed ends curved inwards and joined together to form an inverted domed structure, the tubes being sufficiently close together for molten material to be prevented from escaping from the crucible.

An alternative embodiment of the invention provides a crucible made from a number of tapered tubes of metal of high thermal and electrical conductivity, the tubes being arranged vertically and having their narrowed ends curved inwards and joined together to form a domed structure having a re-entrant depression on the apex thereof, the tubes being sufficiently close together for molten material to be prevented from escaping from the crucible.

In yet another embodiment of the invention there is provided a crucible made from a number of parallel tubes of metal of high thermal and electrical conductivity, the tubes being arranged vertically and spaced close together, but not touching one another, the ends of the tubes being closed, the tubes being of different lengths so that the space bounded by the closed ends of the tubes forms a crucible, the tubes being sufficiently close together for molten material to be prevented from escaping from the crucible.

The invention will be best understood by reference to the following description of embodiments of the invention taken into conjunction with the accompanying drawings wherein:

Fig. 1 illustrates a crucible having an inverted domed construction; and

Fig. 2 illustrates a crucible having a domed construction with a re-entrant depression at the apex thereof; and

Figs. 3 and 4 illustrate a crucible formed by the closed ends of a number of parallel vertical tubes.

The crucible shown in Fig. 1 is formed of a number of hollow tubes 1 which are arranged in a circle with their narrow ends curved

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inwards and communicating with a header compartment 2. The upper ends of the tubes 1 are connected to an annular header compartment 3 which is divided into two or more portions so that cooling fluid may be passed through one portion of the header compartment 3, down half the number of tubes 1 into the bottom header compartment 2 and up the remaining tubes 1 and out through the other portion of the upper header compartment 3. The bottom header compartment 2 is made relatively small in diameter so that the crucible assumes the shape of an inverted dome. The tubes 1 are spaced sufficiently closely together to prevent the escape of molten material from the crucible, the material being retained in the crucible by surface tension. Heating of the crucible is accomplished by placing it inside a closely fitting radio frequency primary coil (not shown) which has the shape of an upturned domed skep. Power is induced through the space between the tubes and also by induction due to the current which flows circumferentially in each tube.

Complete melting of the material in the crucible can be achieved if the base of the crucible is dimensioned to eliminate any unnecessary mass of metal and to allow the radio frequency coil to enclose as completely as possible the underside of the crucible. It may still be necessary to utilize some form of preheating to raise the temperature of the material sufficiently to reduce the resistivity to enable the current in the primary coil to couple directly to the material in the crucible.

An alternative form of crucible shown in Fig. 2 comprises a number of tubes 4 arranged in a substantially similar manner to the crucible shown in Fig. 1, but the complete structure is inverted and the tubes 4 are formed to provide a re-entrant depression 5 in the apex of the structure where they join the header compartment 6. In this case the material to be melted is placed in the re-entrant depression 5 and the crucible is spaced within a radio frequency coil. The top of the structure forms a crucible embodying the principles already described but providing a clear view of the contents during melting.

When melting materials which have a very high surface tension, such as silicon, the charge of material may be considerably in excess of the capacity of the depression 5 without danger of overflow of the molten material.

The crucible shown in Figs. 3 and 4 is formed from a number of parallel tubes 7 which are placed together vertically in a coaxial arrangement. The ends of the tubes 7 are closed and the tube lengths are such that the outer tubes project further upwards than do the inner tubes. The result is a depression 8 bounded by the upper ends of the tubes 7. Cooling is accomplished by flowing liquid through a header compartment 9 which communicates with a series of secondary open-ended tubes 10 which convey the cooling liquid up the inside of the tubes 7. The liquid impinges on the closed ends of the tubes 7 and returns to a second header compartment 11 by way of the axial spacing between the outside of the tubes 10 and inside of the tubes 7. Since the tubes are connected to the cooling fluid supply in parallel there is a very little resistance to the flow of fluid resulting in very efficient cooling of the crucible, so enabling very refractory materials to be processed. The primary coil surrounds the mouth of the crucible as in the previous embodiment.

It is to be understood that the foregoing description of specific examples of this invention is not to be considered as a limitation on its scope.

WHAT WE CLAIM IS:—

1. For processing fusible material, a crucible made from a number of tapered tubes of metal of high thermal and electrical conductivity, the tubes being arranged vertically and having their narrowed ends curved inwards and joined together to form an inverted domed structure, the tubes being sufficiently close together for molten material to be prevented from escaping from the crucible.

2. For processing fusible material, a crucible made from a number of tapered tubes of metal of high thermal and electrical conductivity, the tubes being arranged vertically and having their narrowed ends curved inwards and joined together to form a domed structure having a re-entrant depression on the apex thereof, the tubes being sufficiently close together for molten material to be prevented from escaping from the crucible.

3. For processing fusible material, a crucible made from a number of parallel tubes of metal of high thermal and electrical conductivity, the tubes being arranged vertically and spaced close together, but not touching one another, the ends of the tubes being closed, the tubes being of different lengths such that the space bounded by the closed ends of the tubes forms a crucible, the tubes being sufficiently close together for molten material to be prevented from escaping from the crucible.

4. A crucible according to claim 1, 2 or 3 in which said metal of high thermal and electrical conductivity is silver.

5. Apparatus for processing fusible material which includes a crucible according to claim 1, means for circulating a cooling fluid through the tubes, and a close fitting primary induction coil having the shape of an upturned domed skep for inducing electric currents in the tubes and in the fusible material held in the crucible.

6. Apparatus for processing fusible material which includes a crucible according to claim 2 or 3, means for circulating a cooling fluid

through the tubes, and a primary induction coil for inducing electric currents in the tubes and in the fusible material held in the crucible.

7. A crucible substantially as described with reference to Fig. 1, 2 or 3 of the accompanying drawings.

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For the Applicants.

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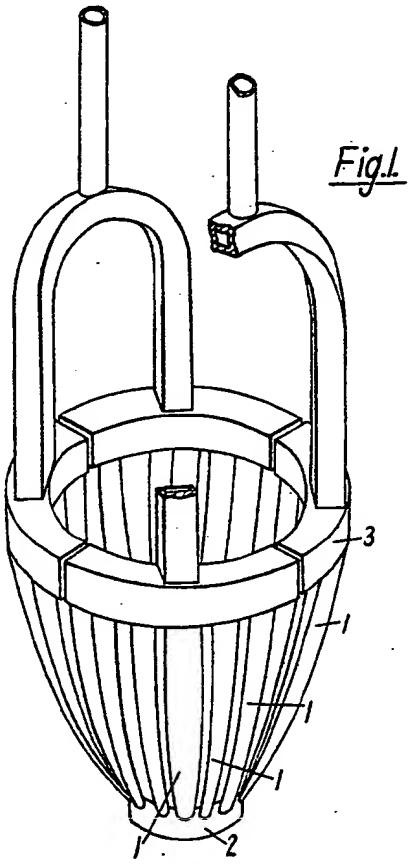
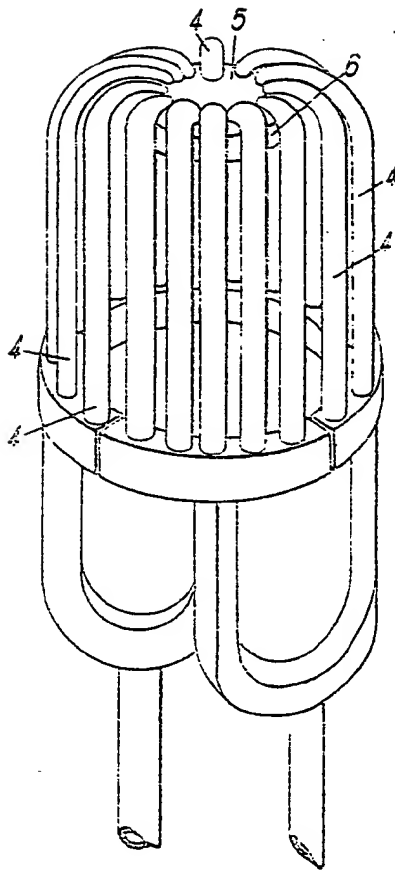


Fig.1.

Fig



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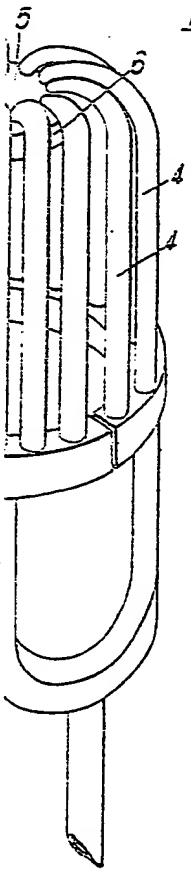
Sheets 2 & 3

Fig.2.



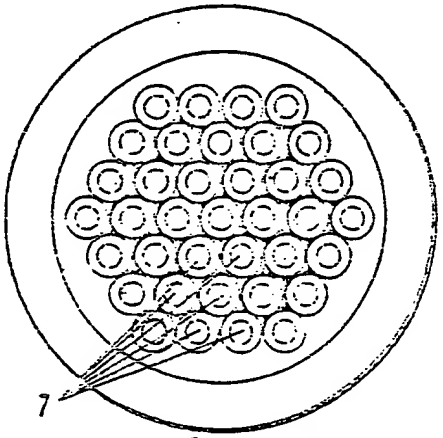


Fig.3.

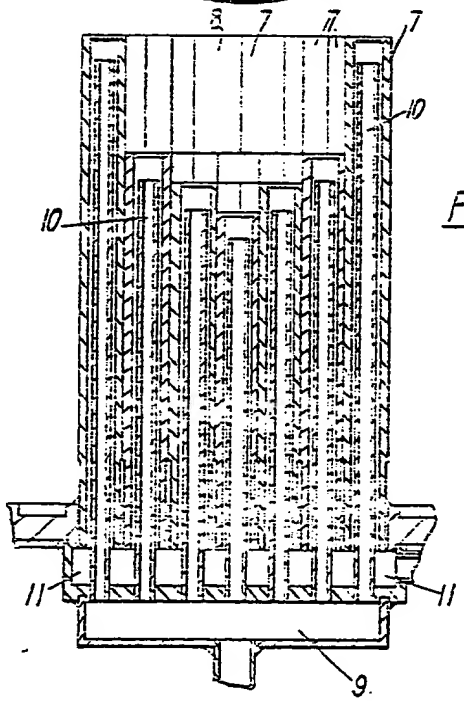


Fig.4.

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Fig.2.

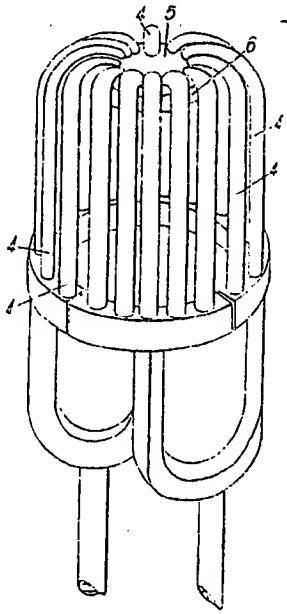

Fig.3

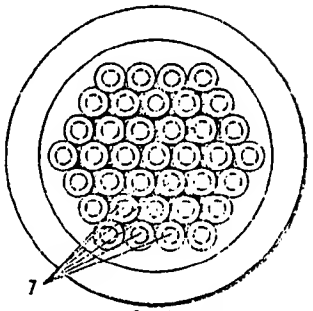

Fig.4.